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Food allergies and sensitivities

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Individuals who have a casual acquaintance with some of the available information about food allergies and sensitivities might perceive that those illnesses are increasing in frequency. Certain events would seem to support that perception. Undeclared sulfite and FD&C Yellow #5 (tartrazine) are two of the most common reasons for food recalls in the United States. Considerable publicity has surrounded the recent recognition that sulfites are involved in asthmatic reactions in some individuals. A few consumer interest groups have focused considerable attention on food allergies and sensitivities, asking, for example, for bans on further use of sulfite and the labeling of "fast-food" restaurant items for the benefit of allergic individuals.

An increasing awareness of food allergies and sensitivities within the medical community has led to an increase in the number of diagnosed cases. A fringe element of the medical community, the medical ecologists, have implicated numerous foods and a long list of other environmental agents in their patients' maladies. Several inappropriate diagnostic procedures, including most prominently the cytotoxicity test, performed widely at storefront "clinics," have also contributed to a widespread perception that the frequency of food allergies and sensitivities is increasing.

However, there is no evidence to indicate that those illnesses are increasing in frequency. Food allergies and sensitivities have been around for quite a while, although some types, such as sulfite sensitivity, were not recognized until recently. The only increases in frequency have probably been associated with the increased use of particular foods or ingredients. For example, soybean allergy may be more prevalent in the United States today than it was a decade ago because of the increased consumption of soybean protein.

Dietitians have a critical role to play both in the diagnosis and in the management of food allergies and sensitivities. An increased understanding of such illnesses will be helpful in fulfilling those roles. The excellent article by Butkus and Mahan in this issue should be required reading for all dietitians. (See page 601.) I have very little to add to this excellent effort.

As correctly noted by Butkus and Mahan, the true food allergies are those reactions mediated by the immune system. Immunological reactions typically involve IgE, although the roles of Type III and Type IV reactions in food allergies remain to be fully elucidated. However, the typical patient may have a very different meaning for the term *food allergy*. Most patients and some physicians use food allergy to describe any adverse reaction to food that is individualistic in nature. The mechanistic involvement of the immune system is ignored in the more general definition. In conversations with patients and physicians, it is important to resolve any potential semantic differences in the use of the term *food allergy*. The importance of that concept stems from differences in the management of true food allergies and other types of individualistic adverse reactions to food.

The symptoms of true food allergies, especially the IgE-mediated reactions, can be quite severe and even life-threatening. Sometimes the tolerance level for the offending food is vanishingly small—zero for all practical purposes. Such patients must be approached cautiously from a diagnostic standpoint. The potential for adverse reactions to open or blinded challenges or even to skin tests may dictate alternative diagnostic approaches. On the treatment side, the exquisitely sensitive patient must carefully avoid all exposure to the offending food. Dietitians can be very helpful in identifying potential sources of difficulty in avoidance diets. Rotary diets may be hazardous for such patients by increasing their level of sensitization to the offending food. Although not everyone with a true food allergy or even an IgE-mediated food allergy will respond in an exquisitely sensitive manner, health professionals should be keenly aware of the potential for such a reaction.

The non-immunological reactions represent a rather diverse collection of mechanisms. The preferred general term for those reactions is food sensitivities, although that term covers both the allergic and the non-allergic types of individualistic adverse reactions to foods. The non-immunological food sensitivities differ in some important ways from the true food allergies. Most important, patients usually display some tolerance for the offending food or ingredient. Consequently, diagnostic challenge proce-

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dures tend to be less risky, although the doses administered in the challenges must still be approached cautiously.

In terms of management, the individuals do not need to be quite so careful in the avoidance of the offending food. A good example is sulfite sensitivity. Sulfite-sensitive asthmatics typically display thresholds in the range of 5 to 200 mg free, inorganic sulfite. A patient with a 200 mg threshold for sulfites would be highly unlikely to react to most sulfited foods because very few would provide the threshold, triggering dose; exceptions would be sulfited lettuce from salad bars, dried fruit, guacamole, and heavily sulfited hash brown potatoes. A patient with a 5 mg threshold for sulfites would have to be more careful but could still consume normal quantities of some sulfited foods, such as maraschino cherries, with little, if any, risk. A complicated situation faces the dietitian trying to provide advice to sulfite-sensitive asthmatics who may have differing thresholds for sulfite.

Another general distinction between non-immunological food sensitivities and true food allergies is the severity of the reaction. Sulfites are an exception in that category because sulfite-induced asthma can be life-threatening. More typically, the non-immunological sensitivities tend to be milder reactions that would not be viewed as life-threatening. Again, this provides some latitude in the choice of diagnostic procedures and the construction of avoidance diets.

The regulatory approaches of the Food and Drug Administration and other federal and state agencies should recognize the distinctions between true food allergies and non-immunological food sensitivities. Since extremely low tolerance levels can exist for true food allergies, it is imperative that allergenic foods be declared on food labels when present. For the most part, this occurs already, although more control of potentially hazardous allergenic residues seems warranted. With the non-immunological food sensitivities, regulations can take note of the fact that finite tolerance levels do exist. Labeling is the most logical method for the regulatory control of all types of food sensitivities. Labeling allows the sensitive individual to avoid products containing ingredients that could trigger reactions.

With adequate labeling regulations in place, the dietitian should be able to design safe and effective avoidance diets for patients with food sensitivities. Dietitians need to play a larger role in the diagnosis and management of food sensitivities. The patients and their allergists would benefit from a closer association with dietitians.

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Food allergies: Immunological reactions to food

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Allergic reactions to food are mediated by the immune system, can be consistently reproduced, and cause a change in the target organ. An estimated 0.3% to 20% of infants are affected. The incidence decreases with age to about 1% to 3% in adults. Development of food allergies depends on heredity, intestinal permeability, immune responsiveness, and exposure to food. Common symptoms include gastrointestinal, skin, or respiratory disturbances that occur from seconds to several hours after food ingestion. Although the skin-prick test is the most reliable diagnostic test, positive results must be followed by a trial elimination diet and food challenge to determine whether symptoms appear after food ingestion. Food allergies are treated by the elimination of the offending foods from the diet. Breast feeding is usually recommended to reduce the incidence of allergic disease in infants. The dietitian's expertise is particularly valuable in assessing the nutritional status of the allergic person, assuring nutritional adequacy during treatment and maintenance, and participating in research to address the many unresolved issues surrounding food allergies.

In the last two decades, improved understanding of the intricate immunological network has led to greater understanding of allergic disease. The purpose of this article is to review the immunological basis for adverse reactions to food or food allergy, and the trends in prevention, diagnosis, and treatment.

About 17% of Americans suffer from some type of allergic disease. The most common are allergic rhinitis (hay fever), which affects about 7%, and asthma, which affects about 4%. Those are usually reactions to inhalants, such as pollen, dust, and mold. Other allergic diseases, including atopic dermatitis (eczema), urticaria (hives), and food, drug, and insect reactions, affect about 6% of the population (1).

Food allergy is most prevalent in infants, is generally mild, and diminishes as the child grows, but the exact incidence of food allergy is unknown. Reports show an incidence as low as 0.3% and as high as 20% in a general pediatric population (2,3). A survey by Gallagher et al. (4) found that about 3% of a general adult population reported some type of adverse reaction to food. About 24% of children and adults with other allergies (hay fever, asthma) report some type of adverse reaction to food (2).

Immunological basis for allergic reactions

There are many adverse reactions to the ingestion of food, including allergic, idiosyncratic, toxic, metabolic, and pharmacologic reactions. *Food sensitivity* is used to refer to all of those adverse reactions to food, as Dr. Taylor explains in his commentary in this issue.[1] The features that distinguish food allergy from other types of adverse reactions to food are the following:

1. It is mediated by an immunological mechanism.
2. It can be consistently reproduced by a blinded food challenge.
3. It causes functional changes in the target organ(s) (3,5).

In general, the intestinal tract provides an effective barrier against the excessive absorption of bacteria, food antigens, and large molecules that normally exist in the intestinal lumen (6). When that mechanism is ineffective, antigens are allowed to enter the system in excessive amounts, which leads to sensitization of the immune system in some individuals (7).

The immune system consists of the bone marrow, bursal-equivalent tissue, thymus, spleen, lymph nodes, tonsils, gut-associated lymphoid tissue (Peyer's patches), and bronchial-associated lymphoid tissue (Luster patches) (8). The bone marrow produces lymphocytes that are processed by bursal-equivalent tissue to produce B-lymphocytes or by the thymus to produce T-lymphocytes. The B- and T-lymphocytes are the basis for the two distinct classic response pathways—the humoral (B-cell) and cell-mediated (T-cell) responses. Although it was first thought that the pathways were separate and distinct, it is now known that they are mutually interdependent (8).

[1]See Taylor, S.L.: Food allergies and sensitivities, p. 599.

The role of T-cells in an allergic reaction to a food is unclear. T-cells generally protect against tumors and help or suppress immunoglobulin production. The cells may play a role in gluten-sensitive enteropathy (7).

In response to an antigen, B-cells produce the immunoglobulins (antibodies) IgA, IgD, IgE, IgG, and IgM that bind the antigen, leading to neutralization, opsonization, complement activation, phagocytosis, or hypersensitivity reactions (8). IgD, IgG, and IgM protect the body against bacteria. IgA in saliva and intestinal secretions prevents absorption of macromolecules. IgE attacks parasites and is the immunoglobulin responsible for the classic allergic reaction (1,3,8).

The four basic types of immunologic reactions are summarized in Table 1 (1). Type I, IgE-mediated reactions, occur most frequently and are the most completely understood. Sensitized IgE binds to mast cells, specialized granular cells in the respiratory tract, skin, and intestines. An allergic reaction occurs when an allergen bridges two molecules of sensitized IgE, causing the cell to release chemical mediators (including histamine) and the cell membrane to release phospholipids. The mediators cause itching, contraction of smooth muscles, dilation of small blood vessels, secretion of mucus, and attraction of eosinophils to the area.

The presence of circulating immunoglobulins, IgG or IgM, sensitized to a particular antigen is a general phenomenon. The antibodies form complexes with antigens; most persons have low concentrations of the antigen-antibody complexes, called *precipitating antibodies*. Their purpose is apparently to clear absorbed food antigens from circulation. Although usually harmless, precipitating antibodies occasionally cause delayed reactions, enteropathies, or chronic pneumonitis (Type III reactions) (7).

Common food allergens

When the number of foods available is considered, the lists of foods commonly reported to cause allergic reactions are remarkably similar. The foods most commonly reported to cause allergic reactions in the pediatric population are cow's milk, chicken eggs, legumes (peanuts and soybeans), wheat, tree nuts (filberts and cashews), and fish (9-11). The studies in adults are limited, but they indicate that shellfish, peanuts, nuts, and grains frequently cause reactions (12,13). A great many other foods have also been implicated as causes of allergic reactions.

Cross-reactivity may occur between different foods, especially between foods in the same biological family. For example, patients allergic to soybeans are often allergic to other legumes. Cross-reactivity of foods and the nature of allergens were recently reviewed by Taylor (14).

Allergens are usually acidic proteins or glycoproteins of a very specific configuration and size (18,000 to 40,000 molecular weight) and one of the most abundant proteins in the food (15). Antigenic activityis believed to reside in a specific series of amino acids that binds with the IgE antibody. The amino acids may be sequential or linear in the protein molecule, or they may be brought into correct sequence by folding of the protein molecule. Denaturing a protein does not seem to reduce its allergenicity when the sequence is linear but does seem to reduce allergenicity when the sequence is caused by folding of

Table 1. Types of allergic reactions (1)

reaction classification	*mechanism*	*comments*
Type I immediate hypersensitivity, anaphylactic, IgE-mediated or reaginic reaction	Allergen binds with sensitized IgE antibody on mast cell, specialized granular cells in the intestines, skin, and respiratory tract, or basophils, similar cells in blood. That results in release of mediators (histamine, eosinophilic chemotactic factor, bradykinin, and so forth). IgG_4 has also been identified as being involved in this type of reaction.	Includes hay fever, anaphylaxis, most food allergies. Symptoms occur within seconds or up to 2 hours. Symptoms of food reactions may include laryngeal edema, vomiting, diarrhea, eczema, itching, bronchospasm, and shock.
Type II cytotoxic	IgG antibody reacts with cell membrane or antigen associated with cell membrane.	Transfusion of incompatible blood types. No food reactions have been demonstrated.
Type III antigen-antibody complex Arthus reaction	Antigen-antibodies (IgG and IgM) form a complex called "precipitating antibody." The antigen-antibody complex is an Arthus reaction when it occurs in soft tissues like blood vessels, lungs, or kidneys and is serum sickness when the complex circulates. Activation of complement also occurs in some instances.	Occurs in some food reactions; milk precipitins have been found in lungs of some children with chronic respiratory infection and in GI tract in those with gastroenteropathies. Reactions usually take 6 or more hours to appear and may take several days to be clinically apparent (7).
Type IV delayed or cell-mediated hypersensitivity	T-cells interact directly with antigen.	Usual mechanism of graft rejection. Possibly involved in some food allergies, such as protein-losing enteropathies, and celiac disease.

the protein molecule (16). Allergens in fish (16), cow's milk (17), chicken egg white (18), peanuts (19), tomatoes (20), and soybeans (21) have been studied to some extent.

The amount of an allergen that remains in the various fractions of a food after processing has not been extensively quantified. Early tests on cottonseed meal proved that it was highly allergenic but that the oil pressed from cottonseed was not allergenic (22). Recent tests have shown that persons sensitive to soybeans and peanuts were not sensitive to the oil of those legumes (23-25).

Symptoms of food allergy

Symptoms of IgE-mediated food allergy can occur within seconds or up to 2 hours after eating a food (26). In delayed hypersensitivity reactions, symptoms may not occur for several hours or even several days (26).

The symptoms of food allergy are listed in Table 2. Minford and co-workers (27) reported that gastrointestinal disturbances as a result of food allergies occurred in 70% of patients, skin reactions in 24%, and respiratory problems in 4%.

Even though atopic dermatitis is often a symptom of food allergy in young children, how frequently it is a result of food allergy in adults is unknown. The symptoms usually diminish by age 12, but 50% to 80% of the children go on to experience asthma or allergic rhinitis (9).

Systemic anaphylaxis, the most dangerous allergic reaction, can occur within minutes to several hours after ingestion of a food. Symptoms can include abdominal pain, nausea, cyanosis, a drop in blood pressure, angioedema, chest pain, urticaria, diarrhea, shock, and even death (26).

It is controversial whether food allergies affect the central nervous system or cause behavioral aberrations, such as schizophrenia (28), migraine headaches (29), or tension-fatigue syndrome (30). Bock (31) found that children's behavioral problems did not occur as the sole manifestation of food allergy; they were secondary to the other symptoms, such as vomiting, hives, or an itchy rash.

Food allergy may also play a role in otitis media in children (32) and cause joint pain and arthritis-like symptoms in adults (33). When those conditions do not respond to other treatments, an evaluation of allergenicity may be warranted.

Environmental factors may explain the variations in symptoms. For example, symptoms of food allergy may appear only during the pollen season (2). Recently, anaphylactic reactions have been observed when a particular food was consumed 1 to 2 hours before heavy physical exercise but not when the food was consumed without physical exertion (34,35).

Table 2. Symptoms of food allergy

gastrointestinal tract
pruritis of lips, oral mucosa, pharynx
swelling of throat
nausea
cramping pain
abdominal distention
vomiting
diarrhea
occult fecal blood loss
protein-losing enteropathy
skin
urticaria (hives)
atopic dermatitis (eczema)
respiratory
asthma
rhinitis
anaphylaxis
controversial symptoms
cerebral/neurological
behavioral disorders
allergic tension-fatigue
schizophrenia
epilepsy
arthritis
otitis media

Development and persistence of food allergy

Development of food sensitivity probably depends on several factors—heredity, gastrointestinal tract permeability, immune system responsiveness, and exposure to food.

In the United States, the chance of a child's being atopic (subject to IgE-mediated reactions) is about 58% when both parents are atopic, 38% when one parent is atopic, and 12.5% when neither parent is atopic (36)—a complex and polygenic inheritance. When both parents have the same allergy symptoms (e.g., asthma), the child usually has the same allergy symptoms (36).

During the first 3 months of life before gut closure occurs, the immature gut of an infant is most permeable to antigens (6). Normal infants fed cow's milk from the first weeks of life show increasing levels of circulating IgG and IgA antibodies to the milk up to the age of 3 to 9 months. Then there is a gradual decline. Later introduction of cow's milk yields lower and delayed peaks, presumably meaning that less food antigen is crossing the intestinal barrier (7).

The literature tends to indicate that exclusive breast feeding reduces the incidence of allergy in infants at risk (36-38). Breast feeding is usually recommended for 3 to 6 months (36). Although most studies conclude that breast feeding lowers the incidence of allergic disease, Kovar et al. (39) found that the design of most of the studies was "seriously flawed and results were conflicting both from study to study and from one indicator condition to another."

In some cases, common food antigens, such as milk and eggs, have gone through the mother's milk and caused reactions in the infant (40). In those cases, having the mother avoid the food alleviated the infant's symptoms.

When breast feeding is not possible, especially for an infant with an allergy to cow's milk, artificial feeding should consist of casein hydrolysate formulas, such as Nutramigen®[2] or Pregestimil®[2] rather than soy formulas (41). Soy is almost as allergenic as cow's milk (42).

Hamburger et al. (36) are currently testing a proposed strategy for reducing allergic reactions in infants at risk that includes exclusive breast feeding for 6 months, with an elimination diet for the mother in some cases. The child should avoid allergenic foods (especially cow's milk,

[2]Mead Johnson Nutritional Division, Evansville, IN.

eggs, wheat, peas, beans, corn, and citrus) for 1 to 1½ years and avoid inhalant allergens as much as possible. Foucard (43) speculates that the greatest effect of a preventive program may be seen in children with a moderate predisposition to allergy. In infants with a pronounced allergic predisposition, environmental control is probably not enough to compensate for the genetic constitution.

Elimination diets for infants and pregnant and lactating women in such preventive programs need to be carefully evaluated for nutritional adequacy. For lactating women, the Recommended Dietary Allowance for calcium is 1,200 mg (44). When a lactating woman is placed on a milk elimination diet, she may require supplements to achieve the recommended allowance.

Animal studies have shown that large doses of antigen are less sensitizing than small doses (46). Thus, a question has been raised as to whether the practice of introducing food to human infants a little at a time should be changed. Since there is still no way to prove IgE sensitization has not occurred *in utero* or from breast milk, there is great risk of eliciting a severe reaction by giving a large dose of an offending food (45,46).

The prognosis for IgE-mediated food allergies that occur before age 3 is good, with about 40% being "outgrown." The eventual tolerance of milk, egg, and soy are common. Food allergies diagnosed after age 3 seem to be more persistent (31,47). Adults have reported reactions that have persisted for 15 years or more (48).

Diagnosis of food allergy

In no instance does the result of a single test determine a conclusive diagnosis of food allergy. The diagnosis of food allergy is based on accumulated evidence that includes the history, physical examination, appropriate immunological and other tests, trial elimination diet, and food challenge, as summarized in Table 3. The diagnostic process has previously been described (2,3,7,14,26, 49,50). Adams and Mahan (50) specifically address the role of the dietitian in the assessment of food allergies.

The dietitian can provide valuable insights during the assessment of the food-allergic patient. A thorough understanding of foods and nonimmunological reactions to foods is particularly valuable during the history taking. Evaluation of nutritional status early in the process is also important.

Infants and children should be evaluated for growth and development as well as for dietary adequacy. Since the parents of the children may have tried a number of elimination diets, the child's diet may be marginal in nutritional adequacy. A child may also be receiving steroids or other medications that may adversely affect nutrient utilization or growth (51). When the patient has no idea which foods are causing symptoms and the symptoms are sporadic, a 2-week food diary that includes a record of symptoms may prove useful.

Immunological tests (summarized in Table 4) may be useful in identifying suspected foods but should always be followed by a trial elimination diet and food challenge to confirm the reaction. Reliable tests include the skin-prick test (3,52-54), the radioallergosorbent test (RAST) (54), and the enzyme-linked immunosorbent assay (ELISA) (55). Bock and co-workers (52) found that a large wheal and flare as a result of the skin-prick test correlated well with actual symptoms following food challenge. RAST and ELISA have about the same level of reliability as skin tests and are particularly useful for people who have experienced anaphylaxis or have skin diseases (54,55).

The cytotoxic test, which is popular at this time, is unreliable (3,14,54). Sublingual (3,54), provocative, and neutralization testing (3,54) also are unreliable. The results of those tests correlate very poorly with symptoms on food challenge and the results of other measures of food allergy (3,54).

Once a list of suspected foods has been obtained, those foods are eliminated from the diet for 2 to 6 weeks, or until the symptoms clear. If the symptoms do not clear with the elimination diet, progressively more restrictive diets (described elsewhere [50]) can be implemented. A hypo-

Table 3. Food allergy assessment

History
Provides detailed description of symptoms, time from ingestion of food to onset of symptoms, most recent reaction, and quantity of food necessary to produce a reaction, and suspected foods.*
Includes family history of allergic disease, enzyme deficiencies, and so forth.*

Physical examination
Includes anthropometric evaluation, assessment of growth and development, and nutritional status.*
Assesses other chronic disease.
Evaluates allergic conditions like allergic rhinitis, eczema, and asthma.

Food and symptom diary for 2 weeks
Provides actual record of food, amount and time when eaten, time of appearance of symptoms, and any medication taken.*
Allows assessment of dietary adequacy.*

Immunological testing (skin tests, RAST, other)
Yields list of suspect foods.
Requires confirmation of positive results by trial elimination diet and food challenge to show clinical sensitivity to food.

Trial elimination diet for 2 to 4 weeks or until symptoms clear
Needs to be nutritionally sound.*
Requires that patient record all ingested food as the suspect food may be ingested in an alternative form.*
Begins with a simple elimination diet. Only foods suspected by history, food diary, and/or immunological testing are eliminated.*
Progresses to more extensive elimination diet if symptoms do not clear on simple diet. Only one food in each of four food groups or exotic foods never before eaten are allowed.*
May require use of hypoallergenic diet (i.e. Vivonex†, Pregestimil‡, Nutramigen‡) if symptoms do not clear on an extensive elimination diet.*

Food challenge
Excludes foods known to cause severe reactions such as wheezing, asthma, or anaphylaxis.*
Returns suspect foods to diet one at a time after symptoms have cleared for 2 to 4 weeks.*
8 to 10 mg (½ to 1 tsp) is given for the first dose.
The amount is increased until it approximates usual intake.
Is repeated following positive reactions as coincident reactions are common.*
Is performed as double-blind challenge when uncertainty about reaction persists.*

*Points in the diagnostic process where the dietitian's expertise may be particularly valuable.
†Norwich-Eaton Pharmaceuticals, Norwich, NY.
‡Mead Johnson Nutritional Division, Evansville, IN.

Table 4. Diagnostic tests

type of test	description	comments
skin testing: scratch, prick, or puncture	A drop of antigen is placed on skin, which is then scratched or punctured.	Considered most sensitive test but overdiagnoses food allergy. Clinical symptoms seen in about 30% of all tests. Should be followed by food challenge (52,53).
RAST (radioallergosorbent extract test)	Serum mixed with food on paper disc and then washed with radioactively labeled IgE.	No more accurate than skin test and more costly. Useful for persons with extremely reactive skin or in cases of anaphylaxis (55).
ELISA (enzyme-linked immunosorbent assay)	Much like RAST, except no radioactively labeled material is used.	Same as RAST (55).
cytotoxic testing	Allergen mixed with whole blood or serum leukocyte suspension; lysed leukocytes are counted.	Unreliable (54).
sublingual testing	Drops of allergen extract placed under the tongue, and symptoms recorded.	Unreliable (54).
provocative and neutralization testing	Subcutaneous injection of extract elicits symptoms followed by weaker or stronger injection to neutralize symptoms.	Unreliable (54).
intestinal biopsy	Histological examination of inflammatory changes of villi.	Diagnostic for celiac disease and enteropathies (2).
precipitating antibodies	Serum levels of IgG, IgA, and IgM detected by double diffusion in agar.	Does not necessarily imply allergy (3).
T-cell evaluation	Serum levels of lymphokines.	Costly; still experimental.

allergenic elemental diet (i.e., Vivonex[3]) may also prove useful (56). If the symptoms continue while the patient is following an elimination diet, the allergy is probably not caused by foods, or at least not caused by the foods that were eliminated from the diet.

When symptoms have cleared, foods are reintroduced, one at a time, and the person is observed for any reaction. The amount of the initial dose should be about ½ tsp to 2 Tbsp fresh food or 10 mg to 2 gm dried food. The amount of *dried* food necessary to evoke symptoms in children has been reported to be 20 mg to 8 gm (10). The amount of fresh food needed to cause symptoms in adults has been reported to be 5 gm (about 1 tsp) to 100 gm (13).

If a reaction is not precipitated by the initial dose, the dose may be increased at each feeding until a reaction occurs or the volume of food is the same as in a normal serving. The patient should be carefully observed while foods suspected of causing allergic reactions are being reintroduced, such a reintroduction has been known to precipitate anaphylactic shock (57).

A double-blind food challenge is necessary when there is a psychological component to the reaction or when symptoms are vague or ill-defined (49,50). Dried food is put into opaque capsules and coded by a third person. Neither the person taking the capsules nor the person administering the capsules knows their content, and then symptoms are recorded. Some researchers advocate double-blind testing as the only reliable method for confirming the symptoms of food allergy (11,31,49).

Nonimmunological reactions to food

In the diagnostic process it is necessary to allow for the possibility of nonimmunological reactions, which probably account for the majority of adverse responses to food (2,3,50). Such reactions may be caused by gastrointestinal disorders, enzyme deficiencies, psychosomatic reactions, bacterial or chemical contamination, or noxious elements in the food. Manifestations include abdominal pain, vomiting, diarrhea, asthma, urticaria, and headache and may mimic those of food allergy (Table 5).

The belief that food additives are responsible for widespread adverse reactions is not substantiated by the literature. Although the mechanism for reactions to food additives is unknown, it appears to be an adverse chemical or drug reaction rather than an immunological response. Only a few additives have repeatedly been implicated in adverse reactions: the yellow azo food dye tartrazine (also called FD&C yellow dye No. 5) (58-65); a few preservatives and antimicrobials, including benzoates (58,62,63,67) and sulfiting agents (68-71); and the flavor enhancer monosodium glutamate (MSG) (72).

Aspirin intolerance has been well documented since the early 1900s. While only 0.3% of a normal population experiences aspirin intolerance (58), those persons seem to be identified most often as also reacting to food additives.

About 15% of aspirin-sensitive individuals are sensitive to tartrazine (58-61), but tartrazine sensitivity has also occurred in those who are not sensitive to aspirin (64,65). Since tartrazine is widely distributed in processed foods and medicines (60), tartrazine sensitivity should be suspected in aspirin-sensitive persons with asthma when the asthma is difficult to control.

It has been reported that ponceau (another azo dye), erythrosine (a non-azo dye), and annatto (a natural color-

[3]Norwich-Eaton Pharmaceuticals, Norwich, NY.

Table 5. Representative nonimmunological reactions to food (3,50)

cause	*associated foods*	*symptoms described*
gastrointestinal disorders		
enzyme deficiency		
lactase	Foods containing lactose and milk.	bloating, flatulence, diarrhea, abdominal pain.
glucose-6-phosphate-dehydrogenase	Fava or broad beans.	hemolytic anemia
disease		
cystic fibrosis	Symptoms may be precipitated by certain foods.	Characteristic of the disease.
gallbladder disease		
enteropathy		
inborn errors of metabolism		
phenylketonuria	Foods containing phenylalanine.	Elevated serum phenylalanine levels, mental retardation.
galactosemia	Foods containing lactose or galactose.	Vomiting, lethargy, failure to thrive.
psychological reactions	Symptoms may be precipitated by any food.	Wide variety; any system may be involved.
reactions to pharmacological agents in foods		
vasoactive amines		
phenylethylamine	Chocolate, aged cheese, red wine.	Migraine headaches.
tyramine	Cheddar cheese, French cheeses, brewer's yeast, chianti wine, canned fish.	Migraine headaches, cutaneous erythema, urticaria and hypertensive crisis in patients on monoamine oxidase inhibitors.
histamine	Fermented cheeses, fermented foods (e.g., sauerkraut), pork sausages, canned tuna, anchovies, sardines.	Erythema, headaches, decreased blood pressure.
histamine-releasing agents	Shellfish, chocolate, strawberries, tomatoes, peanuts, pork, wine, pineapple.	Urticaria, eczema, pruritis.
reactions to food additives		
tartrazine or FD&C Yellow No. 5	Yellow or yellow-orange colored foods, soft drinks, medicine.	Hives, rash, asthma.
benzoic acid or sodium benzoate	Soft drinks and some cheeses, salt-free margarines, and processed potato products.	Hives, rash, asthma.
sulfites		
sodium sulfite	Salad bar lettuce in restaurants, shrimp, many processed foods—avocado, instant potatoes, dried fruits and vegetables, acidic juices, wine, beer.	Acute asthma and anaphylaxis, loss of consciousness.
potassium sulfite		
sodium metabisulfite		
potassium metabisulfite		
sodium bisulfite		
potassium bisulfite		
sulfur dioxide		
monosodium glutamate	Chinese and Japanese dishes.	"Chinese restaurant syndrome"—headache, tenseness in face, sweating, chest pain, and dizziness.
reactions to microorganism contamination of foods		
Proteus causes histidine to break down to histamine-like substance.	Unrefrigerated scombroid fish (tuna, bonita, mackeral). Heat-stable toxin.	Scombroid fish poisoning—itching, rash, vomiting, diarrhea.
Gonyaulax catenella (red tide)	Mussels, clams that ingest organism which produces soxitoxin. Heat stable.	Paralytic shellfish poisoning—progressive numbness from head to arms.

ing agent) have caused hives and have been suspected of causing other reactions (62,66,67).

Antimicrobial preservatives have also been reported to cause adverse reactions. About 23% of aspirin-sensitive subjects are sensitive to the antimicrobial benzoic acid (58); reactions include asthma or urticaria (62,63,67). All benzoic acid-sensitive persons have been aspirin sensitive. Potassium sorbate has not been demonstrated to cause reactions (64); BHA and BHT have inconsistently caused reactions (62,67).

A reaction to sulfur dioxide was reported by Prenner and Stevens (68) in 1976, and several reports of reactions to sulfiting agents have appeared since then (69-71). In the majority of cases, the persons experienced asthma or wheezing, but urticaria and diarrhea have also been reported (71). Many of the reactions have been dose-dependent (71).

Sulfiting agents are used extensively in food processing and in the restaurant industry for their properties as an antioxidant, preservative, and antimicrobial agent (71). Numerous processed foods contain sulfites, including lemon juice, maraschino cherries, fruit drinks, dried fruits

and vegetables, canned seafood, soups, dried potatoes, and frozen avocado. In most states, it is also allowable for restaurants to use sulfiting agents on salad greens, cole slaw, avocado salad, potatoes, and shrimp.

Reactions to MSG, reported in the late 1960s and early 1970s, became known as the "Chinese restaurant syndrome" (72). A recent report indicated that the reaction to MSG may occur only when there is a B-6 deficiency (73).

Management/treatment of food allergy

The treatment of food allergy is elimination of the offending food. Desensitization shots are generally not effective for food, and medication is usually restricted to severe cases (2,3,14).

The level of sensitivity to a food determines how much restriction is needed. People who are exquisitely sensitive must remove all traces of the food from their diets; people with mild to moderate sensitivity may be able to tolerate small amounts of food without a reaction. Those with a mild or moderate allergy to several foods may benefit from a rotation diet, in which a food causing an allergy is eaten only once every 5 days and is alternated with other foods (50).

Careful attention must be given to the adequacy of the diet. Although only a few nutritional deficiencies have been reported in the literature (74-76), the potential is great if multiple foods must be eliminated or if the food eliminated is a major source of nutrients in the diet.

Except in cases of anaphylaxis, foods causing allergies may be reintroduced every 6 months following the protocol for food challenge (Table 3) to see whether the allergy symptoms have decreased and tolerance to the food has developed.

Oral desensitization has not been effective for treating food allergies (3). Cohen et al. (77) described patients who had had severe allergic reactions after eating bee pollen in an attempt to develop oral desensitization (77). The pollen was found to contain dandelion pollen, a member of the ragweed family, and the patients were all found to have significant skin reactions to ragweed pollen. The researchers concluded that pollen-sensitive patients may find it a greater "health hazard than a benefit" to ingest bee pollen.

Use of nutrient supplements in treatment of allergic disease

Controversy has surrounded the idea that ascorbic acid is effective in treating allergies, particularly asthma. A recent study suggested that 1 gm ascorbic acid had a *small* effect on reducing the susceptibility of some *mild* asthmatics to bronchochallenge with methacholine, a powerful stimulant (78). It may be that ascorbic acid is one of several factors that cause a small decrease in airway reactivity, just as smog, cigarette smoke, and upper respiratory tract infections increase reactivity (79).

Implications for the dietitian

To the extent that the dietitian is knowledgeable about and understanding of food allergies, he/she can assume a more active role in patient assessment and education. The patient with allergies can be helped to understand the problem, plan an adequate diet, and live more comfortably. Patient education has been shown to improve the overall management of asthma (80). Presumably, a similar improvement would occur with food allergies.

Knowledge about food allergy has increased greatly in the last few years, but many issues still need to be addressed. There are questions about the incidence of food allergies, whether food allergies are worse during the pollen season, and whether they cause cerebral or neurological symptoms. Concern exists about the effect of breast feeding on preventing or delaying food allergies. There are also political and ethical issues about whether newly developed engineered foods should be tested for allergenicity and what the risk-benefit ratio should be. The dietitian can be a key person in resolving such issues, eradicating the myths that surround food allergies, and working with the food industry in making foods safer for persons with allergies.

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After reading the Continuing Education article, "Food allergies: Immunological reactions to food," please answer the following questions by indicating your responses on the Self-Assessment Questionnaire Answer Form located on the next page. ADA members should return the completed form, with a check for $6 (non-members $10) to cover processing, to: The American Dietetic Association, P.O. Box 10960, Chicago, IL 60610-0960.

This activity has been approved for 1 hour of continuing education credit by the Commission on Dietetic Registration. Answers to the self-assessment questionnaire can be found on page 718.

Questionnaires must be returned within 1 year of their appearance in the *Journal* in order to be eligible for credit. Notification will not be sent if hour is approved.

Questions 1 to 6

For questions 1 to 6, select the *best* answer or completion to each question or statement.

1. The most common allergic disease found in Americans is:
   A. Atopic dermatitis
   B. Food allergy
   C. Urticaria
   D. Allergic rhinitis
   E. Asthma
2. Although the exact incidence of food allergy in pediatric populations is unknown, it is estimated to be about:
   A. 0.3% to 20%
   B. 3%
   C. 17%
   D. 24%
3. The immunoglobulin responsible for the classical allergic reaction is:
   A. IgA
   B. IgD
   C. IgE
   D. IgM
   E. None of the above
4. The most common symptoms in food reactions involve:
   A. Skin reactions
   B. Gastrointestinal disturbances
   C. Respiratory problems
   D. Behavioral disorders
   E. None of the above
5. A conclusive diagnosis of food allergy can be made by which of the following immunological tests alone?
   A. Radioallergo-sorbent extract test (RAST)
   B. Cytotoxic test
   C. Skin-pinch test
   D. Enzyme-linked immunosorbent assay (ELISA)
   E. None of the above
6. The treatment of choice for food allergy is:
   A. Oral desensitization
   B. Elimination of the offending food
   C. Densensitization shots
   D. A hypoallergenic elemental diet for 2 to 6 weeks
   E. None of the above

For questions 7 to 12 select:

A. If 1, 2, and 3 only are correct
B. If 1 and 3 only are correct
C. If 2 and 4 only are correct
D. If 4 only is correct
E. If *all* are correct

7. Among foods commonly reported to cause allergic reactions are:
   1. Fish and shellfish
   2. Cow's milk, soy milk, and eggs
   3. Tree nuts and peanuts
   4. Grains
8. When diagnosed before age 3, allergic reactions to the following foods have frequently been outgrown:
   1. Cow's milk
   2. Chicken eggs
   3. Soybeans
   4. Fish
9. Research on food allergens has produced which of the following findings?
   1. Cross-reactivity may occur between foods in the same biological family
   2. The amount of allergen in foods appears to be resistant to food processing
   3. Denaturing may decrease the allergenicity if a particular molecular structure of the allergen is present
   4. The molecular structure of the allergens in food appear in a variety of sizes and configurations
10. The onset of the most common type of food allergy:
    1. Can occur within seconds of eating a food
    2. May *not* occur for several days in cases of delayed hypersensitivity
    3. Can occur up to 2 hours after eating a food
    4. Are unaffected by environmental factors
11. Which of the following are recognized factors in the development of food sensitivity?
    1. Exposure to food
    2. Gastrointestinal tract permeability
    3. Heredity
    4. Immune system responsiveness
12. The development of food allergy in children is usually marked by:

1. A greater prevalence when both of the child's parents are food sensitive
2. A decreased incidence following breast feeding
3. A better prognosis when the child has a relatively moderate predisposition to allergy
4. A better prognosis if the food allergy develops after age 3

Questions 13 to 20

For questions 13 to 20, there are several groups of items. Each group consists of a list of lettered headings followed by a list of numbered statements. Select the lettered heading that is most closely related to each numbered statement. In each group of items, a lettered heading may be used once, more than once, or not at all.

Reaction classification

A. Type I—IgE mediated reaction
B. Type II—cytotoxic reaction
C. Type III—antigen-antibody complex formation
D. Type IV—cell-mediated reaction
E. None of the above

Mechanism or feature in food reactions

13. Food reactions result from precipitating antibodies
14. Most food reactions result from this mechanism

Diagnostic test for food allergy

A. Skin test
B. Radioallergo-sorbent extract test (RAST)
C. Cytotoxic testing
D. Precipitating antibodies

Usefulness in diagnosing food allergy

15. Completely worthless, in the authors' opinion
16. Most sensitive test

Causes of non-immunological reactions to foods

A. Histamine-releasing agents
B. Sulfites
C. Tyramine
D. Lactose
E. None of the above

Symptoms

17. Headache, urticara, and hypertensive crisis in patients receiving monoamine oxidase inhibitors
18. Bloating, flatulence, diarrhea, abdominal pain
19. Acute asthma and anaphylaxis, loss of consciousness
20. Urticaria, eczema, pruritis

Continuing Education Article
"Food allergies: Immunological reactions to food"
Journal, May 1986
SELF-ASSESSMENT QUESTIONNAIRE ANSWER FORM
Article Expiration Date: May 1987

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Mail this form, with check or money order in the amount of $6 ($10 for non-ADA members) to cover processing, to:
The American Dietetic Association
P.O. Box 10960
Chicago, IL 60610-0960

After reading each statement, please select the one best answer or completion:

1.	A	B	C	D	E
2.	A	B	C	D	E
3.	A	B	C	D	E
4.	A	B	C	D	E
5.	A	B	C	D	E
6.	A	B	C	D	E
7.	A	B	C	D	E
8.	A	B	C	D	E
9.	A	B	C	D	E
10.	A	B	C	D	E
11.	A	B	C	D	E
12.	A	B	C	D	E
13.	A	B	C	D	E
14.	A	B	C	D	E
15.	A	B	C	D	E
16.	A	B	C	D	E
17.	A	B	C	D	E
18.	A	B	C	D	E
19.	A	B	C	D	E
20.	A	B	C	D	E